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PROVISIONAL APPLICATION COVER SHEET

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METHODS AND APPARATUSES FOR TRANSMIT LATENCY REDUCTION IN WIRELESS COMMUNICATION SYSTEMS

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METHODS AND APPARATUSES FOR TRANSMIT LATENCY REDUCTION IN WIRELESS COMMUNICATION SYSTEMS

BACKGROUND

[0001] The present invention relates generally to wireless communication systems and, more particularly, to systems and methods for reducing transmit latency reduction in wireless communications.

[0002] Technologies associated with the communication of information have evolved rapidly over the last several decades. For example, over the last two decades wireless communication technologies have transitioned from providing products that were originally viewed as novelty items to providing products which are the fundamental means for mobile communications. Perhaps the most influential of these wireless technologies were cellular telephone systems and products. Cellular technologies emerged to provide a mobile extension to existing wireline communication systems, providing users with ubiquitous coverage using traditional circuit-switched radio paths. More recently, however, wireless communication technologies have begun to replace wireline connections in almost every area of communications. Wireless local area networks (WLANs) are rapidly becoming a popular alternative to the conventional wired networks in both homes and offices.

[0003] Circa 1990, the IEEE 802 standards committee formed the 802.11 Wireless Local Area Networks Standards Working Group to develop a global standard for radio equipment and networks operating in the 2.4 GHz unlicensed frequency band for data rates of 1 and 2 Mbps. After its introduction, the various versions of the 802.11 standard rapidly formed the basis for standardization of WLAN networks and devices.

[0004] One important consideration in wireless communication systems are techniques for avoiding data packet collisions and handling them when they arise. The IEEE 802.11 standard for wireless networks has adopted a data collision avoidance mechanism which involves listening to other mobile devices that are transmitting to the access point and attempting collision avoidance through the use of random back-off timeouts. Collision avoidance is accomplished by requiring each device desiring to transmit to first choose a random value from within a range specified in the IEEE 802.11 standard. Each such device must then wait this random period of time following the previous transmission before commencing. Although this technique does help to avoid collisions, it also negatively effects the latency associated with data packet transmission because it adds additional transmit delay.

[0005] Accordingly, it would be desirable to develop wireless communication systems and methods which reduced transmit latency while still providing for collision avoidance.

SUMMARY

[0006] Systems and methods according to the present invention address this need and others by providing communication systems that that reduce latency associated with packet transmission. Random backoff time can be reduced by monitoring and subtracting medium idle time. Various medium idle time sources can be selectively enabled and considered.

[0007] According to one exemplary embodiment of the present invention, a method for transmitting a packet in a wireless communication system includes the steps of: measuring an idle time of a transmission medium, reducing a delay time by the idle time and transmitting said packet at said reduced delay time.

[0008] According to another exemplary embodiment of the present invention, a device for transmitting a data packet includes an idle timer for measuring an idle time of a transmission medium, a start controller for reducing a delay time associated with transmission of the data packet by said idle time and a transmitter for transmitting said packet at said reduced delay time.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The accompanying drawings illustrate exemplary embodiments of the present invention, wherein:

[0010] FIG. 1 depicts a WLAN system in which the present invention can be implemented;

[0011] FIG. 2 depicts an exemplary start controller unit according to an exemplary embodiment of the present invention; and

[0012] FIG. 3 is a flowchart illustrating an exemplary method for transmitting data packets according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION

[0013] The following detailed description of the invention refers to the accompanying drawings. The same reference numbers in different drawings identify the same or similar elements. Also, the following detailed description does not limit the invention. Instead, the scope of the invention is defined by the appended claims.

[0014] In order to provide some context for this discussion, an exemplary WLAN system will first be described with respect to Figure 1. Those skilled in the art will appreciate, however, that the present invention is not restricted to implementation in WLAN systems. Therein, a wireline network 10 (e.g., an Ethernet network) has a file server 12 and workstation 14 connected thereto. Those skilled in the art will appreciate that typical wireline networks will serve numerous fixed workstations 14, however only one is depicted in Figure

1 for simplicity. The wireline network 10 is also connected to a WLAN 16 via router 18. The router 18 interconnects the access points (AP) of the WLAN 16 with the wireline network, through which the access points can, for example, communicate with the file server 12. In the exemplary WLAN system of Figure 1, three cells 20, 22 and 23 (also sometimes referred to as a Basic Service Set (BSS) or Basic Service Area (BSA) are shown each with a respective AP, although those skilled in the art will once again appreciate that more or fewer cells may be provided in WLAN 16. Within each cell, a respective AP serves a number of wireless stations (W) via a wireless connection.

[0015] According to exemplary embodiments of the present invention, the transmission of signals between APs and respective wireless stations W is performed using wireless communication signals in accordance with one of the 802.11 standards. However, those skilled in the art will appreciate that the present invention is not so limited and may be implemented for communication of signals in accordance with other formats and standards. An exemplary transmit control unit 30 is shown in Figure 2. Therein, a start controller timer unit 32 generates a start pulse which instructs a transmitter (not shown) associated with a wireless station W to transmit a data packet over the transmission medium. According to these exemplary embodiments, the transmission medium includes wireless transmission channels, e.g., as defined by IEEE 802.11, however those skilled in the art will appreciate that the present invention can be implemented in communication systems and methods wherein different mediums are involved. The start controller timer 32 also sends transmit parameters, e.g., a parameter which informs the transmit control unit 30 where, in memory, the package to be transmitted is located, the data rate, preamble type, etc., to the transmitter with the start

pulse. The start controller timer unit 32 has a number of different inputs that are used to determine when the start pulse is sent to the transmitter. These inputs include an initial (A)IFS time, a start trigger, an initial backoff time value, a medium busy signal and a total idle time input. Each of these inputs to start controller unit 32 will now be described.

[0016] The initial (A)IFS time is a value which indicates the amount of time the medium needs to be idle, e.g., based on the medium busy signal, before the backoff timer can start running. More specifically, IFS refers to interframe spacing and this value prevents the start controller unit from identifying a space between transmissions as an indication that the medium is busy. The start trigger is an indication that a data packet has been prepared for transmission and that the transmit/backoff timers from this package can be activated. The initial backoff time indicates the amount of time that the medium needs to be idle after the (A)IFS time has expired before a transmission can start.

[0017] The medium busy signal is generated when one (or more) of (optionally) a plurality of medium busy source generators 34 indicate that the transmission medium is being used by other wireless stations W. Examples of medium busy source generators 34 include (1) the (inverted) PHY CCA (physical clear channel assessment) signal, which indicates if another transmit control unit 30 is transmitting via the medium, (2) the running of the NAV (network allocation vector) counter, which is an indication about how long a transmitting station has reserved the medium, (3) an indication that another start controller 32 has an active status, (4) an indication that a ATIM (announcement traffic indication message) period is ongoing, (5) a signal that a Bluetooth device is transmitting or has indicated that it will transmit soon, etc.

[0018] As will also be seen in Figure 2, each medium busy source 34 also can have a respective source sensitivity enabling signal associated therewith. This permits each medium busy source 34 to be selectively enabled or disabled by ANDing the output of the medium busy source 34 with its respective enable signal via AND gates 36. The outputs of AND gates 36 are then input to OR gate 38 to generate the medium busy signal. This permits the start controller unit 32 to be selectively operated in different modes which consider different sets of activities to make the medium busy relative to this particular wireless station W. For example, consider that the medium busy sources include a first medium busy source 34 which indicates that the medium is busy when the PHY CCA signal is active and a second medium busy source 34 which indicates that the medium is busy when another transmit control unit 30 is active. Under certain situations, it may be desirable to generate a medium busy input to start controller 32 when either the PHY CCA signal is active or the other transmit control unit is active, e.g., when the other transmit controller 30 has a higher transmit priority than this transmit controller 30. Under other circumstances it might be desirable to generate a medium busy input to start controller unit 32 only when the PHY CCA signal is active, but not when the other transmit control unit is active e.g., when the other transmit control unit 30 has a lower transmit priority than this transmit control unit 30. Thus, in the latter case it may be desirable to disable the medium busy source 34 associated with the lower priority transmit control unit 30. This feature of exemplary embodiments of the present invention provides start controller units 32 which programmable flexibility so that they can be used in various applications. For example, different start controller units 32 can have different sets of medium busy sources signals enabled to provide different transmit behaviors, e.g., different

priorities between different transmit queues, to permit the transmission of packages only during the ATIM period, to permit the transmission of data packages only during the CFP, etc. The various source sensitivity enable signals shown in Figure 2 can be generated by, for example, software programmable registers (not shown).

[0019] The idle timer 40 tracks the amount of time that the medium has been idle after the start controller unit 32 has become inactive and sends a total idle time signal to the start controller timer unit 32 which indicates this total time. Like the medium busy signal generation mechanism described above, the idle timer 40 can have a plurality of medium busy sources 42 which provide inputs thereto. These medium busy sources 42 may be the same as, partially the same as or completely different than the medium busy sources 34. Additionally, each medium busy source 42 can be selectively enabled or disabled by providing an idle timer source sensitivity signal associated with each of the medium busy sources 42. The idle timer source sensitivity signals are then logically ANDed with their respective medium busy source 42 in gates 44, before being input to OR gate 46. Thus, if any one of the enabled medium busy sources 42 indicates that the medium is busy, the OR gate 46 outputs an idle timer medium busy signal to the idle timer 40 to stop the timer. When none of the enabled medium busy sources 42 indicate that the medium is busy, then the value output from OR gate 46 will invert, enabling the idle timer 40. According to another exemplary embodiment of the present invention, when OR gate 46 indicates that the medium is idle, the idle timer 40 is reset back to zero. In this case the idle timer 40 will instead indicate the amount of time which has passed since the idle timer medium busy signal indicated an idle medium.

[0020] Like the source sensitivity signals input to AND gates 36, the idle timer source sensitivity signals input to AND gates 44 can be selectively enabled and disabled using, e.g., software programmable registers. This provides flexibility in the operation of the transmit control unit 30. Whereas the enablement mechanisms for the medium busy sources 34 described above can, for example, operate as a function of characteristics (e.g., priority) of other start controller units 32, the idle timer source sensitivity signals may not be based on such characteristics and, therefore, can be separately programmable.

[0021] Having described an exemplary transmit control unit 30 according to an exemplary embodiment of the present invention, a method for transmitting data packets according to an exemplary embodiment of the present invention will now be described with respect to the flowchart of Figure 3. Therein, when a start trigger signal is received by start controller unit 32, indicating that a data packet has been generated for transmission, the start controller 32 reads the initial (A)IFS value and the initial backoff time value at step 50. The start controller unit 32 then subtracts the amount of time that the medium has been busy as indicated by the idle timer 40. The idle time value can first be subtracted from the initial (A)IFS value and, if there is remaining idle time, it can be subtracted from the initial backoff value as indicated by step 52. If the result is zero or less, then the transmission of the data packet can begin immediately at step 54. Otherwise, the remaining (A)IFS and backoff time is used as the starting point for the downcounting timer (not shown) provided in start controller unit 34. When the downcounting timer reaches zero, then the data packet is sent at step 54. According to another exemplary embodiment of the present invention, the idle time may only be subtracted from the backoff time rather than the sum of the backoff time and the

(A)IFS time. According to a still further exemplary embodiment, a programmable minimum required remaining backoff /IFS time may be provided for after the subtraction, such that an immediate transmission is prevented.

[0022] If, during the downcounting of the reduced delay time, the start controller unit 32 receives an indication that the medium becomes busy from OR gate 38, then the downcounting is suspended. Once the medium becomes idle again then, after waiting for a period equal to the initial (A)IFS time, the downcounting is resumed. The downcounter value at this time can, for example, either be the same value which remained in the downcounter when the operation was suspended or it can be that value rounded up to the nearest multiple of a slot time duration associated with the channels defined for transmission via the medium.

[0023] The above-described exemplary embodiments are intended to be illustrative in all respects, rather than restrictive, of the present invention. Thus the present invention is capable of many variations in detailed implementation that can be derived from the description contained herein by a person skilled in the art. For example, although hardware devices are described in the exemplary embodiments set forth above, those skilled in the art will appreciate that all, or portions of, the functionality described above can instead be implemented in software. All such variations and modifications are considered to be within the scope and spirit of the present invention as defined by the following claims. No element, act, or instruction used in the description of the present application should be construed as critical or essential to the invention unless explicitly described as such. Also, as used herein, the article "a" is intended to include one or more items.

WHAT IS CLAIMED IS:

1. A method for transmitting a packet in a wireless communication system comprising the steps of:

measuring (50) an idle time of a transmission medium;

reducing (52) a delay time by said idle time; and

transmitting (54) said packet at said reduced delay time.

2. The method of claim 1, wherein said step of measuring an idle time further comprises the step of

providing a plurality of medium idle input signals to a counter; and

counting a time period during which at least one of a predetermined number of said plurality of medium idle signals indicates that said resource is idle.

3. The method of claim 2, further comprising the step of:

selectively enabling each of said medium idle signals to provide said predetermined number of said plurality of resource idle signals.

4. The method of claim 1, wherein said step of subtracting said idle time further comprises the step of:

generating said delay time as the sum of a backoff time and an I(AFS) initial time.

5. The method of claim 1, further comprising the step of

transmitting packet at said transmit time if said medium is not busy at said transmit time.

6. The method of claim 5, further comprising the steps of:

generating a plurality of medium busy status signals; and

generating a medium busy signal when at least one of a predetermined number of said plurality of medium busy status signals indicates that the resource is busy.

7. The method of claim 6, further comprising the step of:

selectively enabling each of said medium busy status signals to provide said predetermined number of said plurality of medium busy signals..

8. A device for transmitting a data packet comprising:

an idle timer (40) for measuring an idle time of a transmission medium;

a start controller (32) for reducing a delay time associated with transmission of said data packet by said idle time; and

a transmitter for transmitting said packet at said reduced delay time.

9. The device of claim 8, further comprising:

a plurality of medium idle signals (42) input to said idle counter (40), wherein said idle counter (40) counts counting a time period during which at least one of a predetermined number of said plurality of resource idle signals indicates that said resource is idle.

10. The device of claim 9, further comprising:

means for selectively enabling each of said resource idle signals to provide said predetermined number of said plurality of resource idle signals.

11. The device of claim 8, wherein said start controller generates said delay time as a sum of a backoff time and an I(AFS) initial time.

12. The device of claim 8, wherein said transmitter transmits said data packet at said reduced delay time if said medium is not busy at said transmit time.

13. The device of claim 12, further comprising:

a plurality of resource busy status signals which are used to generate a resource busy signal when at least one of a predetermined number of said plurality of resource busy status signals indicates that the resource is busy.

14. The device of claim 13, further comprising:

means for selectively enabling each of said resource busy status signals to provide said predetermined number of said plurality of resource busy signals.

ABSTRACT

Systems and methods according to the present invention provide communication systems that reduce latency associated with packet transmission. Random backoff time can be reduced by monitoring and subtracting medium idle time. Various medium idle time sources can be selectively enabled and considered.

Figure 2 for publication.

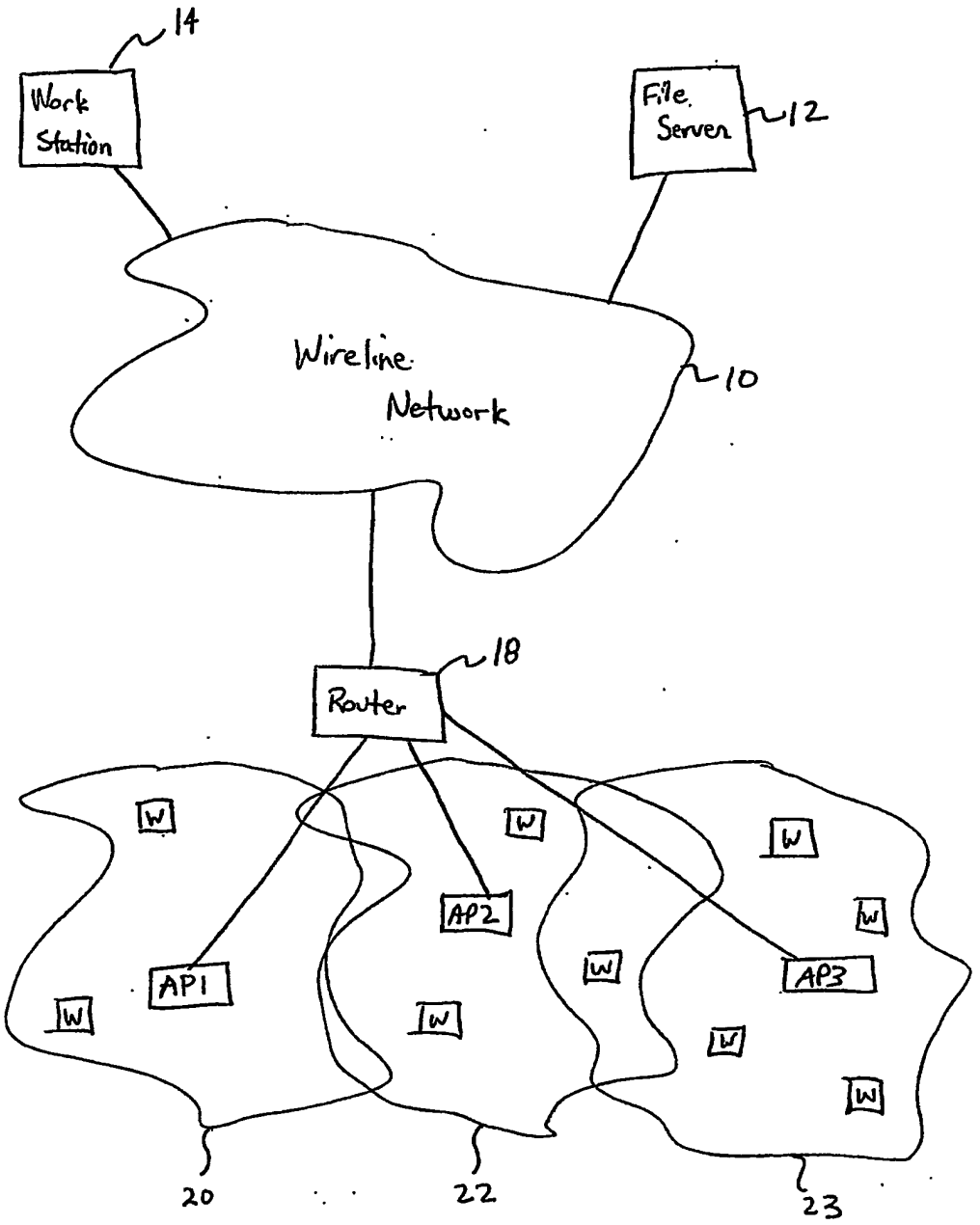
14
Work Station
File Server
12
Wireline Network
10
18
Router
W
AP1
AP2
AP3
20
22
23

FIG. 1

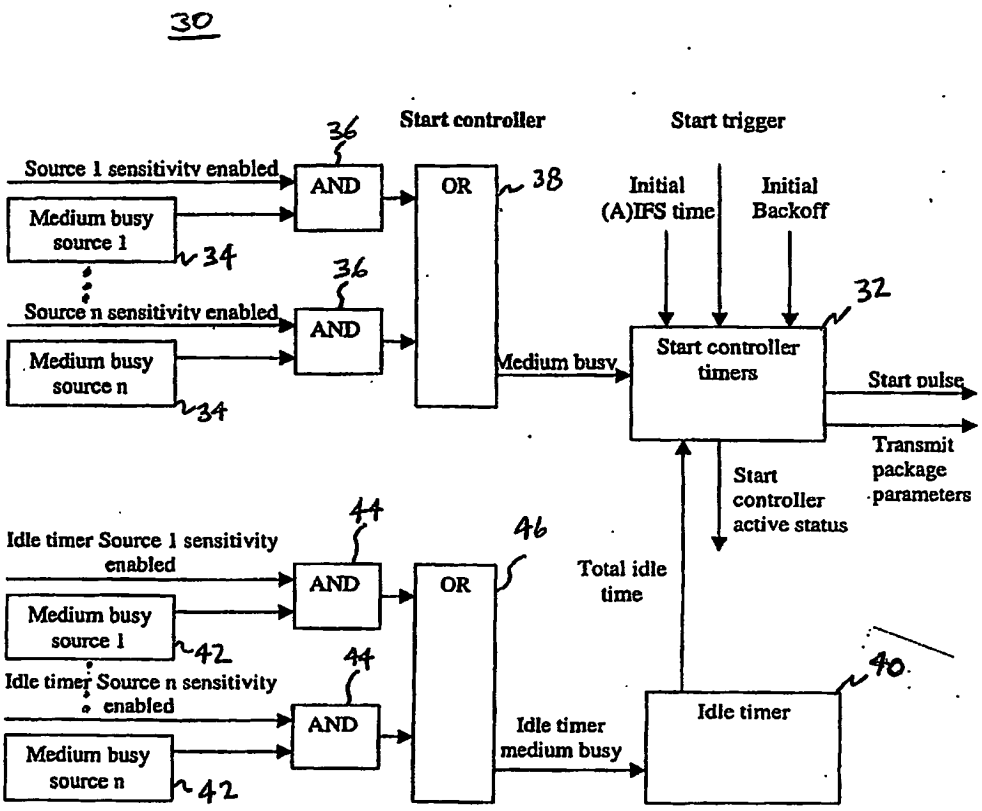
30
Start controller
Start trigger
36
Source 1 sensitivity enabled
Medium busy source 1
34
AND
OR
38
Initial (A)IFS time
Initial Backoff
Source n sensitivity enabled
Medium busy source n
34
AND
Medium busy
Start controller timers
32
Start pulse
Transmit package parameters
Start controller active status
Idle timer Source 1 sensitivity enabled
Medium busy source 1
42
44
AND
OR
46
Total idle time
Idle timer Source n sensitivity enabled
Medium busy source n
42
44
AND
Idle timer medium busy
Idle timer
40

Fig. 2

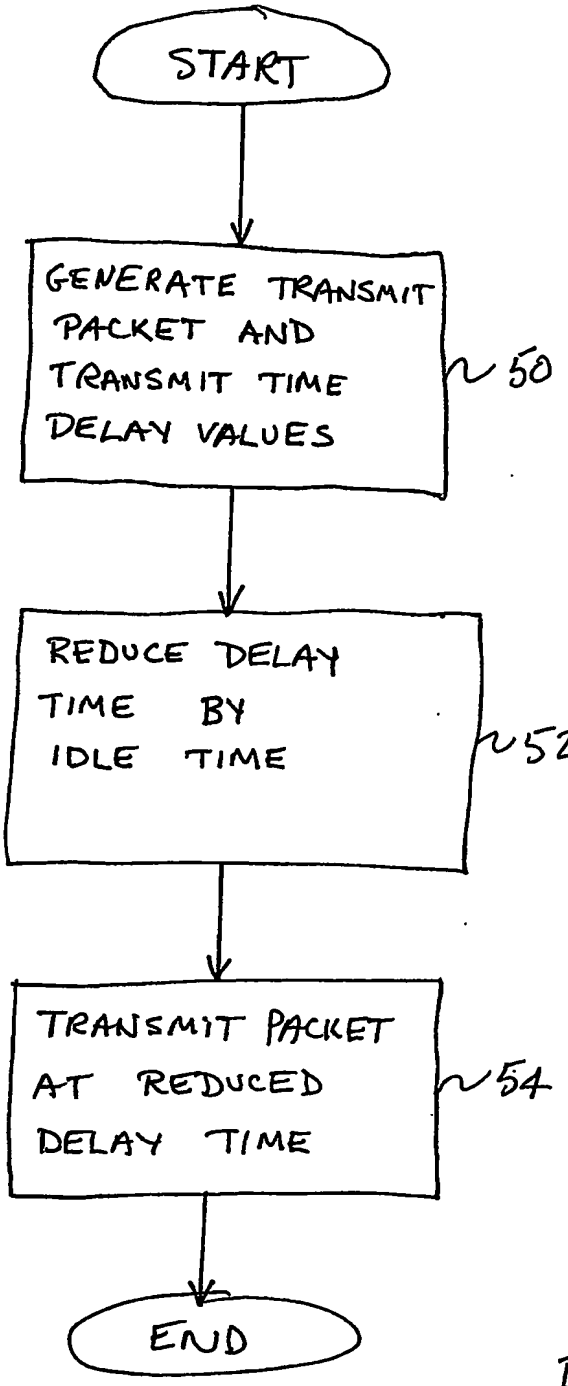
START
GENERATE TRANSMIT PACKET AND TRANSMIT TIME DELAY VALUES
50
REDUCE DELAY TIME BY IDLE TIME
52
TRANSMIT PACKET AT REDUCED DELAY TIME
54
END

Fig. 3